

## 6.0 EMERGENCY PREPAREDNESS

Dams should be designed, monitored, and maintained so that they do not fail. However, conditions beyond the control of the dam owner and engineer can occur due to unforeseen structural problems, natural forces, mistakes in operation, negligence, or vandalism. Therefore, all dam owners should be prepared for emergencies that could occur. The degree of preparedness and the extent of the action taken during emergencies depend, in part, on the potential hazard that may be imposed on the downstream areas. The dam hazard classification system can help a dam owner prepare for emergencies by providing an indication of the potential for downstream losses and damage. It is very important for the dam owner to monitor the dam's hazard classification on a regular basis to determine if new downstream development affects the safety hazards of the dam. The emergency preparedness of a facility reflects the dam owner's ability to respond effectively to emergencies. Small, low hazard dams may require very little or no emergency preparedness. All dam owners should assess and regularly review their emergency preparedness in order to define the hazards that a dam represents and to reduce potential loss of life and property.

In preparing emergency plans, two types of failures are usually considered: rainy day and sunny day failures. A rainy day failure could occur when heavy precipitation, in excess of that normally observed in the watershed above the dam, leads to a high runoff period. If the high water overtops the dam or adds too much pressure, a rapid breach failure could result. The dam owner should be alert to severe weather warnings and inspect the dam before, during, and after such events.

A normal storm event could lead to overtopping the dam if the outlet works are plugged with debris, if the gates jammed or were broken, or if a power failure prevented operation of key mechanisms. All the items can be controlled by proper management and maintenance of the dam.

Dams have also failed without any heavy precipitation. These failures are called sunny day failures. They are usually the result of neglected inspection programs and poor maintenance and operation of the dam. As an example, failure to consider embankment seepage could lead to piping (internal erosion). A sunny day failure could be caused by vandalism of the outlet works, such as damage to gate mechanisms, or if the outlet works are plugged with debris. Sunny day failures are more likely at unattended dams than frequently visited dams.

The components of a facility's emergency preparedness may be grouped into three categories for ease of discussion: 1) site conditions, 2) site procedures, and 3) emergency preparedness equipment.

Site conditions include:

- downstream hazard classification
- access

- security

Site procedures include:

- Management and maintenance plan
- emergency action plan
- operating logbook
- operator training

Emergency preparedness equipment includes:

- communications systems
- warning systems
- auxiliary power systems
- remote operation
- reservoir drawdown capability

### **Site Conditions**

A downstream hazard classification is a rating (e.g. low, significant, or high hazard) that indicates the probable loss of life and property damage downstream from a dam, based on the results of breaching studies of the dam and/or an identification of the area downstream that would be inundated. The dam's condition, or potential for failure, has no bearing on hazard classification. Greater emergency preparedness measures should be performed for dams with higher hazard classifications. Compared to dams with low hazard classifications, high hazard dams should be inspected more frequently and be given a higher priority for any necessary corrective actions. The dam owner should monitor downstream development for potential changes in the dam's hazard classification.

Access to the dam includes the capability of dam personnel to reach the site under adverse conditions and the transportation of construction equipment and material to the site in the event of an emergency, if the nature of the emergency makes averting or alleviating dam failure possible. In an emergency, successful execution of an Emergency Action Plan (EAP) will depend upon emergency personnel and equipment being able to freely access all areas of the site. Access is also important for the normal duties of site operations, maintenance, and inspection personnel. Seasonal access should be available during winter months and periods of heavy or prolonged precipitation. Alternative access routes may be required in the event that the normal access route may be affected by the emergency.

At a minimum, a dam's security system should effectively prevent vandals or saboteurs from gaining access to and operating or damaging dam electrical and mechanical operating equipment. This is particularly important at critical facilities, such as water supply reservoirs and power generation facilities. In the past, protection from vandalism had been the primary reason for site security. However, recent events have clearly

shown that sabotage and terrorism is a distinct possibility. Vandals or saboteurs may damage or operate equipment at a project, or even threaten the safety of the dam directly, and thus jeopardize downstream residents and property. The security of a project against such potential acts must be assessed and appropriately addressed before such incidents occur. A security assessment evaluates the potential threats to the dam, identifies the potential consequences of a successful attack, and looks at the vulnerabilities of the dam to attack. It is in the best interests of security that a dam have a security plan that identifies the features of the dam that are critical to its purpose and the countermeasures that have been implemented to eliminate, reduce, or mitigate the security risk to the dam.

### **Site Procedures**

The Management and Maintenance (M&M) Plan (see Part 2) is a document containing instructions for normal management and maintenance of the dam and its appurtenant works. A dam and its components should be operated and maintained according to design intent. Faulty operation or lack of maintenance could create an emergency or dam safety problem. The M&M Plan should contain all necessary plans, instructions, and guidelines for operating all components of the dam, as well as security provisions. The Plan should also provide details and schedules for maintenance, repairs, and inspections. Regardless of how simple a piece of equipment may be to operate, instructions should be prepared and included as part of the dam's M&M Plan. The adequacy of operating instructions, including those for operation with auxiliary power, should be evaluated for both normal and emergency conditions. The operating instructions should be clear and readily accessible to the site and emergency personnel. If at all possible, the M&M Plan should be kept at the site where necessary. The operating equipment at some dams is of such a basic nature that no posted operating instructions are required. At other facilities, posted operating instructions are deliberately avoided in case unauthorized persons were to gain access to the equipment. In those cases, considerable downstream damage might result from such unauthorized operation. However, trespassers still might operate equipment even without posted instructions, so the proper approach in those circumstances would be to improve security at the site. The dam owner or operator is responsible for preparing and maintaining the M&M Plan. An M&M Plan should be prepared for all dams in Indiana, no matter how simple the dam construction and operating procedures are.

The Emergency Action Plan (EAP) contains procedures to be followed if structural problems, equipment malfunctions, or a natural event such as a flood or earthquake causes the design limits of a dam to be approached or exceeded. Generally, the EAP defines emergency warning and notification procedures to provide a clear set of instructions for emergency personnel to: take action at the dam site in response to emergencies such as floods, earthquakes, or equipment or structural failures such as piping; and, notify designated owner or agency personnel of the emergency and issue warnings to public officials responsible for evacuation. The EAP is typically a component of the M&M Plan, although it may be beneficial to keep it as a separate document to facilitate its use. The dam owner or operator is responsible for preparing

and maintaining the EAP. An EAP should be prepared whenever there is a risk to downstream life and/or property, especially if the dam has a high hazard classification. An EAP is a set of procedures for responding to an emergency. Outdated, confusing, or incomplete procedures and instructions could result in an ineffective response to an emergency; therefore the EAP should be reviewed and updated on a regular basis. A sample outline of an EAP is included in Appendix C of Part 1 of the Indiana Dam Safety Inspection Manual.

Emergency action plans for dam failures should contain the following six topics:

- 1) Introduction
- 2) Identification of Emergency
- 3) Preventive Action
- 4) Notification and Coordination
- 5) Evacuation
- 6) Emergency Termination and Follow-Up

The goals of the EAP are to prevent loss of life and to minimize property damage. Keeping a dam from failing is the best way to prevent loss of life and property damage. Therefore, emphasis must be placed on saving the dam from failure. The dam owner is responsible for drafting the plan, providing copies to participants, coordinating emergency actions, and activating the plan immediately when a failure threatening situation is reported. Since the owner of the dam is responsible for damages caused by the uncontrolled release of water from a dam failure, a written EAP is recommended for all high and significant hazard dams.

Preplanning for an emergency may require a detailed analysis by a qualified dam safety professional. The dam professional can analyze and determine flooding that would happen after a dam failure. He or she will prepare flooding, or inundation, maps to be used for the evacuation portion of the emergency action plan. The analysis will also predict and map flood wave height and speed. All affected downstream landowners and buildings will be identified to develop a list of who to contact with flood warnings and evacuation notices.

A directory of these and any other agencies involved should be established which lists the home phone, address, and office phone of the primary and secondary contacts for each, as well as a listing of the equipment and/or service they can provide and stating an estimate of their response time. This directory should be updated as needed.

Dam incidents should be reported immediately by the person discovering the dangerous condition to the person responsible for executing the emergency plan (listed on the data sheet and in the EAP). The person who first discovers what appears to be a potentially hazardous condition at a dam site may have little or no background in dam design, construction, or safety. In order to be able to properly identify a potentially dangerous condition, it is necessary that dam tenders and others who visit the site regularly are familiar with all features of the dam and dam site. This is especially true for dams with a

history of leakage, cracking, settlement, misalignment, and erosion from wave action. Also, it is necessary to have knowledge of measurements of significant drain and seepage outflows to act as a basis for meaningful comparisons. The person that reports a dam incident should provide clear and concise information concerning the incident, including:

1. Name of dam, lake, or reservoir, and river, stream, or tributary the dam is located on.
2. Location from highway or nearest town (U.S., State, or county road numbers); also section, township and range, if known.
3. Nature of the problem (e.g., excessive leakage, cracks, sand boils, slides, wet spots, etc.).
4. Location of problem area in terms of embankment height, (e.g., about 1/3 up from the toe) and location along the dam's crest (e.g., 100 feet to the right of the outlet or abutment) and whether on the upstream slope, crest, or downstream slope.
5. Extent of the problem area. This can be satisfactorily established by pacing.
6. Estimated quantity of unusual flows as well as whether the water is clear, cloudy, or muddy.
7. Water level in the reservoir below the dam's crest or below the spillway, or the gauge rod reading.
8. Whether or not the water level in reservoir is rising or falling.
9. Name and how to contact person making report.
10. Whether or not the situation appears to be worsening while being observed.
11. Whether or not the problem appears to be a containable problem at the time, or whether it is an emergency situation.
12. Current weather conditions at the site.
13. Anything else that seems important.

An operating logbook should be kept and maintained at a dam to record all operations and maintenance performed, as well as inspections, the occurrence of unusual incidents or observations, and site visitation. The logbook can be very useful to help identify potential safety problems. Every facility should maintain a permanent record of the activities at the facility so that their occurrence along with pertinent information can be referenced when needed. Operating logbooks should be bound and recorded with a ballpoint pen, and should include the date of the activity or incident and signature of the person making the entry. Mistakes should be crossed out with a single line followed by the correct text. The logbook should be stored at the dam where practicable in a secure, moisture-free location.

Recurring training for the dam operator and backup(s) is important to ensure that they understand their responsibilities with regard to operating and maintaining the dam and responding to emergencies. The training should provide sufficient information for the dam operators to make knowledgeable, correct, and prompt decisions concerning protection to the downstream residents and property. Both the principal operator(s) and designated backups should receive operator training in accordance with organizational

policy. New operators should be trained before assuming duties at a dam. The training should include the following as may be applicable:

- general dam safety overview, and site specific potential failure modes and their precursors
- inspection responsibilities, including any specific concerns
- operations and reservoir regulation
- maintenance requirements and practices
- operating logbook
- safety
- site security
- Emergency Action Plan and responsibilities
- reading instrumentation, if required
- public relations and recreation management, if required
- familiarization with the project and equipment
- review of the facility operating procedures
- operation of all equipment

### **Emergency Preparedness Equipment**

The adequacy of emergency preparedness equipment is fundamental to the successful execution of an EAP. The EAP should contain a list of available equipment, or potential contractors that would be utilized during an emergency. The EAP prepared by the dam owner/operator must contain descriptions of the following equipment as applicable:

**Communications Systems:** The available communications systems must be adequate during adverse situations to serve the needs of persons or organizations responsible for emergency operations. Communications systems form the link between a dam, the project or owner's office, and the authorities responsible for the safety of the affected population downstream of the dam. If a threatening situation develops, immediate communication from the site may allow time for flood preparation or evacuation. Failure of communications equipment could have disastrous consequences. Consequently, backup communications should be provided for high hazard dams.

**Warning Systems:** Dams may have electrical/mechanical devices to alert onsite or remote personnel of adverse conditions. However, dam attendance is the major means of warning for most sites. Some means must exist to detect a developing emergency and convey a warning to persons responsible for taking emergency actions. Electrical/mechanical warning systems may be included in project instrumentation, but most sites rely upon warnings transmitted by site personnel. Without warnings, evacuation or preventative actions may be delayed or made impossible. Relatively few dams have electrical/mechanical devices to warn of potential adverse conditions at a site.

**Auxiliary Power Systems:** In the event of failure of the primary power system, auxiliary power, which could be manual operation, must be available to operate mechanical

equipment and lighting and communications equipment, if necessary. If normal power is disabled during an emergency, auxiliary power may be needed to operate equipment such as gates and communications facilities. Ability to carry out the EAP could be severely hindered without auxiliary power. Two common types of auxiliary power systems are: engine generator set and engine-driven pump

**Remote Operation:** Remote operation is the ability to operate equipment, such as spillway gates, from a location other than the dam site. The ability to control equipment such as spillway gates or outlet works gates from a location away from the dam permits timely response to emergencies requiring the operation of this equipment, particularly if someone is not at the dam all the time, and access to the site is relatively difficult. If remote operation is a part of the EAP, the system must operate reliably when needed. Remote operating facilities are not common. Remote operation may also involve visual monitoring using stationary cameras with remote television display.

**Reservoir Drawdown Capability:** The ability to lower the reservoir rapidly during an emergency is vital to emergency preparedness. If design or equipment problems make reservoir drawdown unacceptably slow, the dam could fail and release a full or nearly-full reservoir. For some dam-threatening conditions, such as piping, lowering the reservoir quickly could prevent failure or reduce the effects of failure.

The downstream effect of a dam failure can be devastating. When a break in a dam (breach) develops, water discharge increases due to the uncontrolled release of water stored by the dam. Destruction of homes and property has been well publicized. The force of water through existing bridges and culverts and over roads can cause their collapse. It has been documented that the flood wave from a small dam can overtop roads and wash cars from the roadway. Overtopping of the roads also makes them impassable for emergency vehicles. Dam failures can kill people.

Damage to the environment and to upstream users from a dam failure can also be catastrophic. A breach in the dam and rapid loss of the impounded water can cause heavy silt loads to be passed downstream. These sediments, after a period of time, will settle out, clogging and covering the flooded land and streambed. Fish and wildlife habitat can also be damaged. Upstream slopes can fail and boaters could be washed downstream.